# Effects of Ship's Envelope on Wind Measurements

LT Tim Anderson
OC3570
19 March 2001

## Introduction

Studying meteorological conditions at sea invariably involves measuring wind speed and direction from some point on a ship's structure. These measurements are likely affected in various ways by the structure of the ship. When wind passes over an irregularly shaped object (such as a ship's structure) the resulting wind vectors can be significantly altered due to vortices, eddies, funneling, and shearing. Measurements of wind values at different locations on the ship's structure under various wind conditions may provide enough information to determine the ship structure's effects, and predict the distortion caused in future wind measurements.

## Methodology

To ascertain the effects of a ship's structure on wind measurements, measurements were taken at designated positions on the *R/V Pt. Sur* under various wind conditions. A handheld AN/PMQ-3C Wind Measuring Set was utilized to take measurements of both wind speed and direction at eight positions on *the R/V Pt. Sur* (Figure 1). This instrument consists of a rotating head, a meter that converts the rotations to a wind magnitude. The meter has a switch that changes the scale from a lower setting (for winds under 10 kts.) to a higher setting (for winds in excess of 10 kts. A free-floating indicator inscribed with a compass rose allows the user to determine the relative direction of the wind. These measurements were augmented with the readings from the Windbird anemometer permanently installed on the ship's instrument platform above the flying bridge. The values from this instrument are automatically averaged over a ten second interval.

The positions for taking wind measurements on the *R/V Pt. Sur* were chosen to represent a wide variety of effects. The eight positions were the bow, forward of the port breezeway, forward of the starboard breezeway, aft of the port breezeway, aft of the starboard breezeway, aft of the CTD gantry, the port quarter, and the starboard quarter (Figure 1). The measuring procedure consisted of recording the Windbird data and the course of the ship, then taking measurements at each position on the ship within a reasonable timeframe (usually less than three minutes). The Windbird measurements and recorded course were then compared with corresponding Windbird and course readings after all measurements were taken, to ensure no great change had occurred during the measurement time period. If a great change in either course or wind measured from the Windbird had occurred, the data was not kept and a new data set was recorded.

## Data

The data set consisted of ten sets of measurements, with a total of ninety magnitude/direction pairs, along with ten corresponding ship courses and times (Table 1). Data was organized both according to measurement position and time. Magnitudes for all hand-held measurements were normalized with the corresponding Windbird reading, and also converted to x-y components using each position's respective wind direction. Graphical representations of the wind direction, magnitude, normalized magnitude, x- and y-components of the velocity and normalized magnitude vs. wind direction were constructed.

## Analysis

Wind Direction (All positions): Two measurements 0857 and 0910 on 12 Feb showed much less variation than other measurements. These winds originated from the ship’s starboard and port quarters, respectively. Although these two showed some similarity, other events from the same direction showed higher variance. No definitive tendencies could be determined from the recorded data. The wide variation in wind direction observed did not yield any patterns (Figure 2).

Wind Magnitude (All positions): Again, the two measurements from 0857 and 0910 on 12 Feb showed much less variation than other measurements, but as with direction, nor other correlation could be associated with these two events. Magnitude variations as high as twice the Windbird velocities were observed in some cases (Figure 3).

Position 1: The position on the bow yielded wind speeds that seemed to follow a general pattern- slightly lower than the Windbird levels (likely due to the lower altitude) and relatively stable. This is likely due to the relative lack of structure near the measurement site when compared to the other positions (Figure 4).

Position 2: This position yielded wind speeds usually at or less than the Windbird, especially from the 140-220 degree arc. This may be due to the shadowing of the large ship structure and the breezeway. No other discernable trends (Figure 5).

Position 3: This position showed lower speeds from angles where the ship was both blocking the wind and when the wind came directly at the measurement site. Again, the graph shows a high variance in levels and minimal pattern development (Figure 6).

Position 4: Showed two low speeds near the same direction (~120 degrees) but no other correlation (Figure 7).

Position 5: This position showed a high variance in normalized wind speeds coming from very similar directions. At ~10 and 180 degrees, measurements show a variance between 1.4 and 0.6 the magnitude of the Windbird measurement (Figure 8).

Position 6: Again, a high variability from measurements in similar directions. At 40-50 degrees and 125-135 degrees, differences from 1.2 to 0.2 and 1.5 to 0.8 were observed (Figure 9).

Position 7: This data set shows a majority of wind speeds below the Windbird values, but no set pattern (Figure 10).

Position 8: This set shows some grouping of magnitudes between 0.6 and 0.8, but also has values well outside of that range in similar directions (Figure 11).

## Conclusion

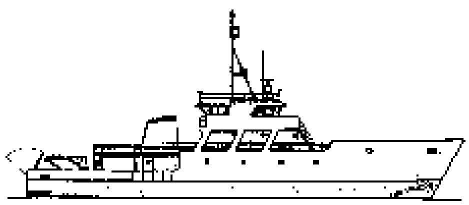
The recorded data shows a significant amount of variance, likely due to disturbances in the wind caused by the ship’s structures. Aside from this general conclusion, no significant patterns were detected. The reasons behind this are numerous. The hand-held anemometer measurements contained inherent inaccuracies. The highest accuracy with the hand-held anemometer was +/- 1kt and +/- 10 degrees. During each measurement, both the speed and direction of the wind was varying, and during the time required to record measurements at nine different positions (including the Windbird sensor) the wind fluctuated noticeably. Some slight averaging was required to get readings, especially during periods when the wind was gusty. Course fluctuations also occurred during some measurements of +/- 5 degrees. All these errors, though probably not the primary cause, may have contributed to the inability to determine a set pattern for wind propagation around the ship. The likely cause of such variability is the changing conditions around the ship. A steady wind combined with a steady ship's course might possibly yield a pattern if numerous measurements are taken. Measurements where the underlying conditions (i.e. wind speed/direction, ship's course, etc.) are constantly changing provide a difficult environment for determining a pattern of any sort.

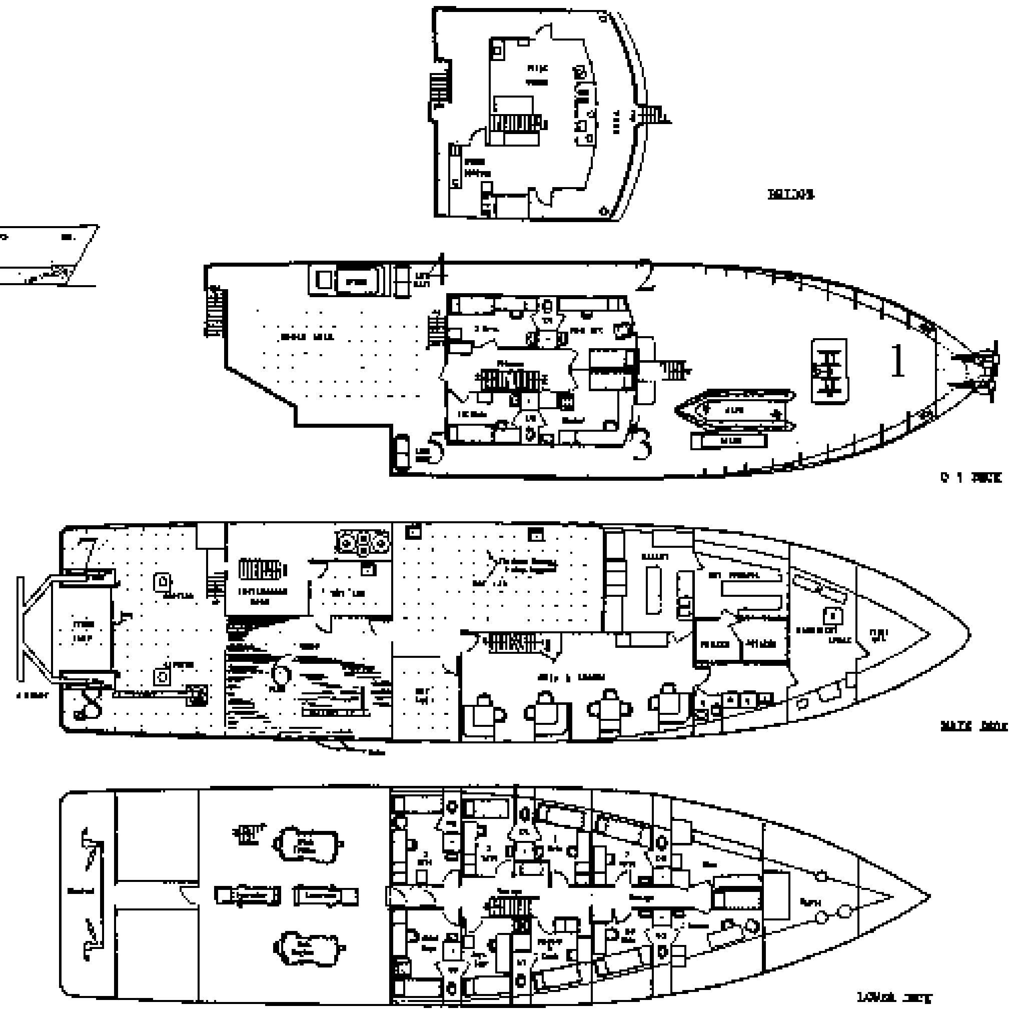
Future attempts to chart wind patterns around ships should probably be comprised of at least the following elements:

1. Continuous measurements from all positions simultaneously, to reduce temporal fluctuations in measurements.
2. A much larger data set, to provide the ability to compute best-fit lines, ratios, etc.
3. Attempts to get significant data sets with the same/similar wind speed/direction and the same course throughout.

The ship's structure definitely has an effect on measuring wind. If any pattern exists among the disturbances, it will be found in future projects.

**Figure 1:**

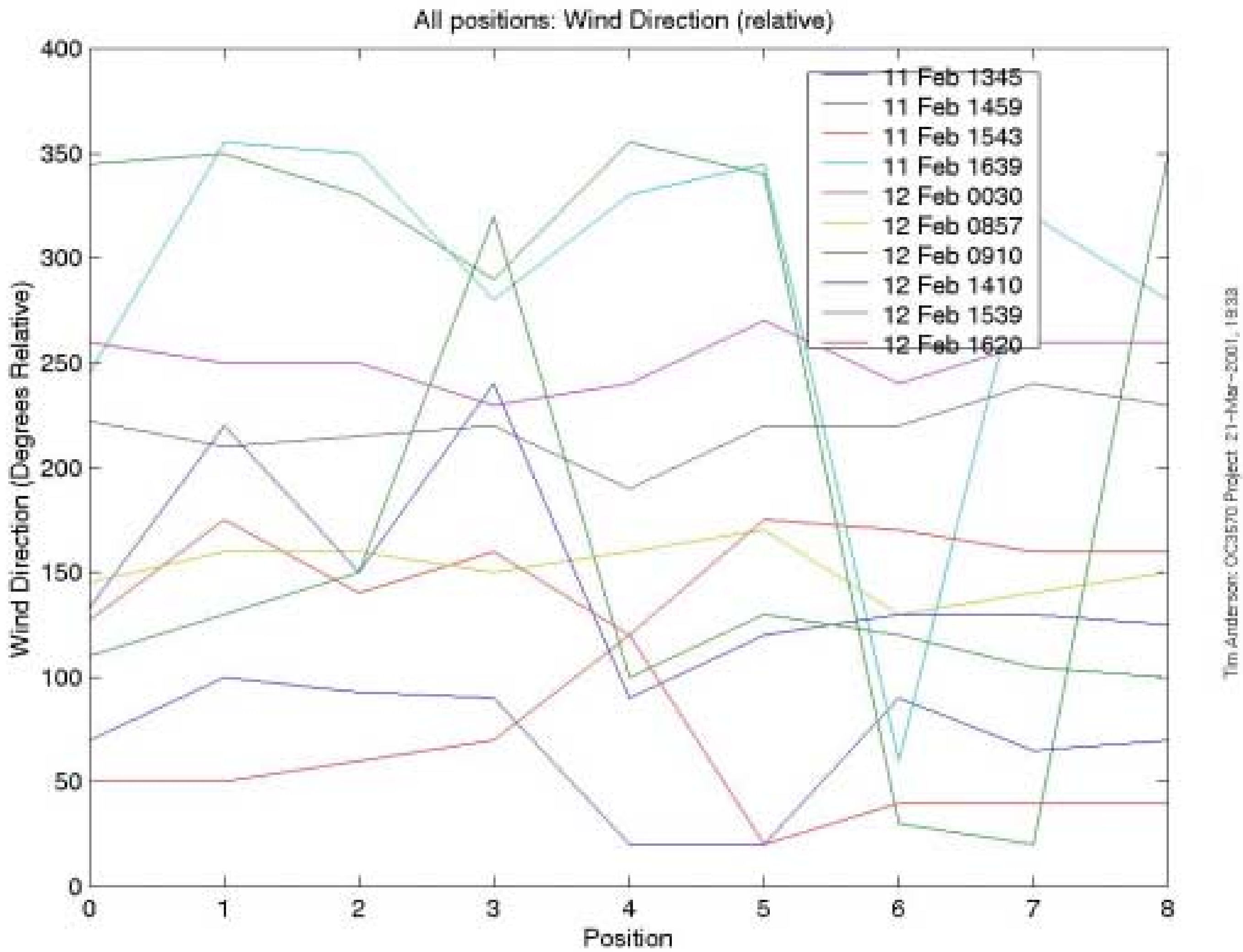




## GENERAL DATA:

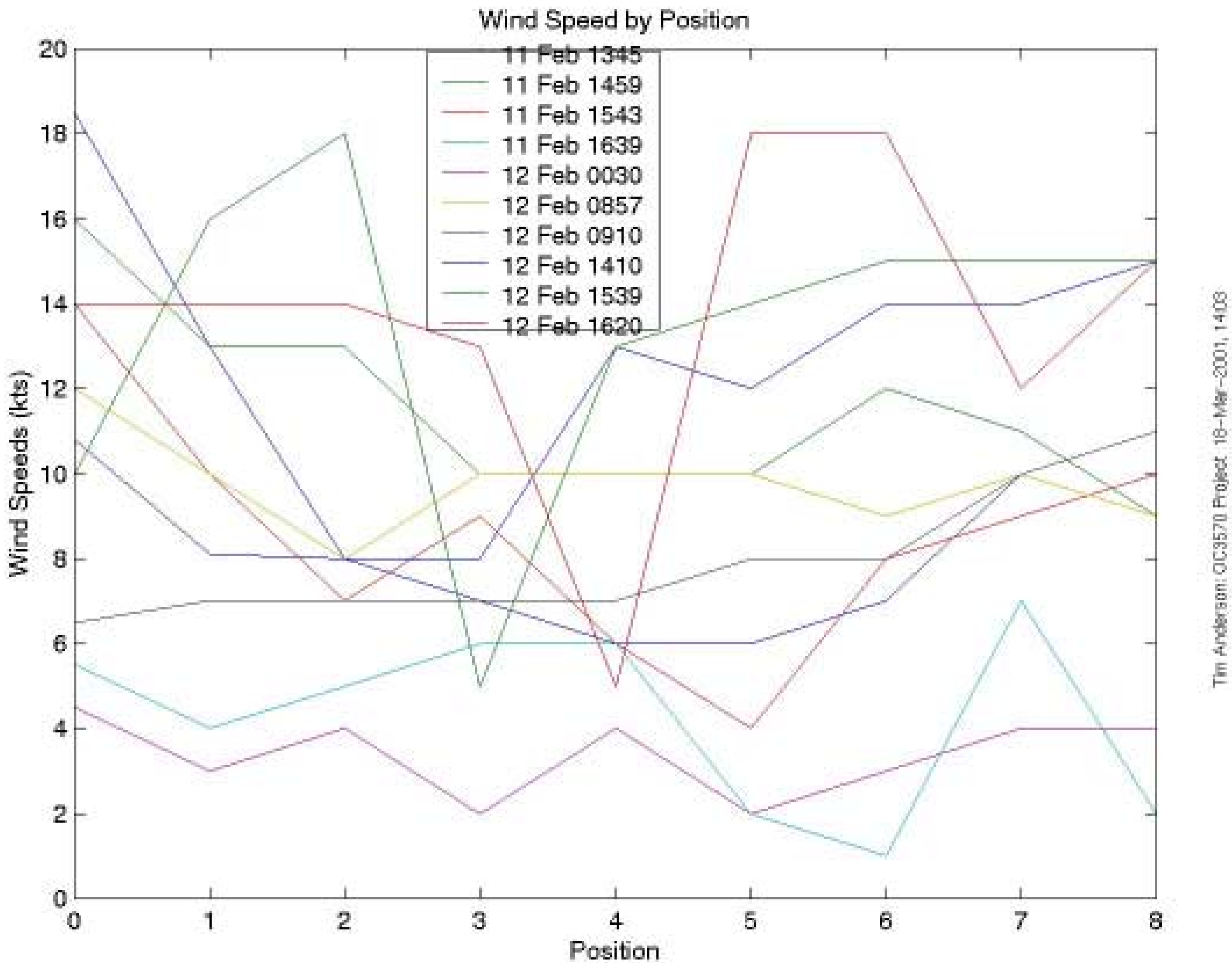
| | |
|---|---|
| LENGTH OVERALL | 135 feet |
| LENGTH BETWEEN PERPENDICULARS | 124 feet |
| BEAM | 32 feet |
| DRAFT (FULL LOAD) | 9 feet |
| GROSS TONNAGE | 294 tons |
| DISPLACEMENT (FULL LOAD) | 539 light tons |
| MAXIMUM SUSTAINED SPEED | 11.5 knots |
| MANEUVERING SPEED | 0-10 knots |
| CRUISING RANGE (NORMAL) | 5,000 n. miles |
| ENDURANCE (NORMAL) | 21 days |
| LABORATORY AREA | DRY LAB 480 sq. ft.<br>WET LAB 100 sq. ft. |
| MAIN DECK AREA | 1500 sq. ft. |
| CREW | Nine |
| SCIENTIFIC BERTHING | Twelve |
| OWNER | National Science Foundation |
| OPERATOR | Moss Landing Marine Laboratories for CENCAL |
| BUILT | 1980 |
| HOME PORT | Moss Landing, California |

**Figure 2:**



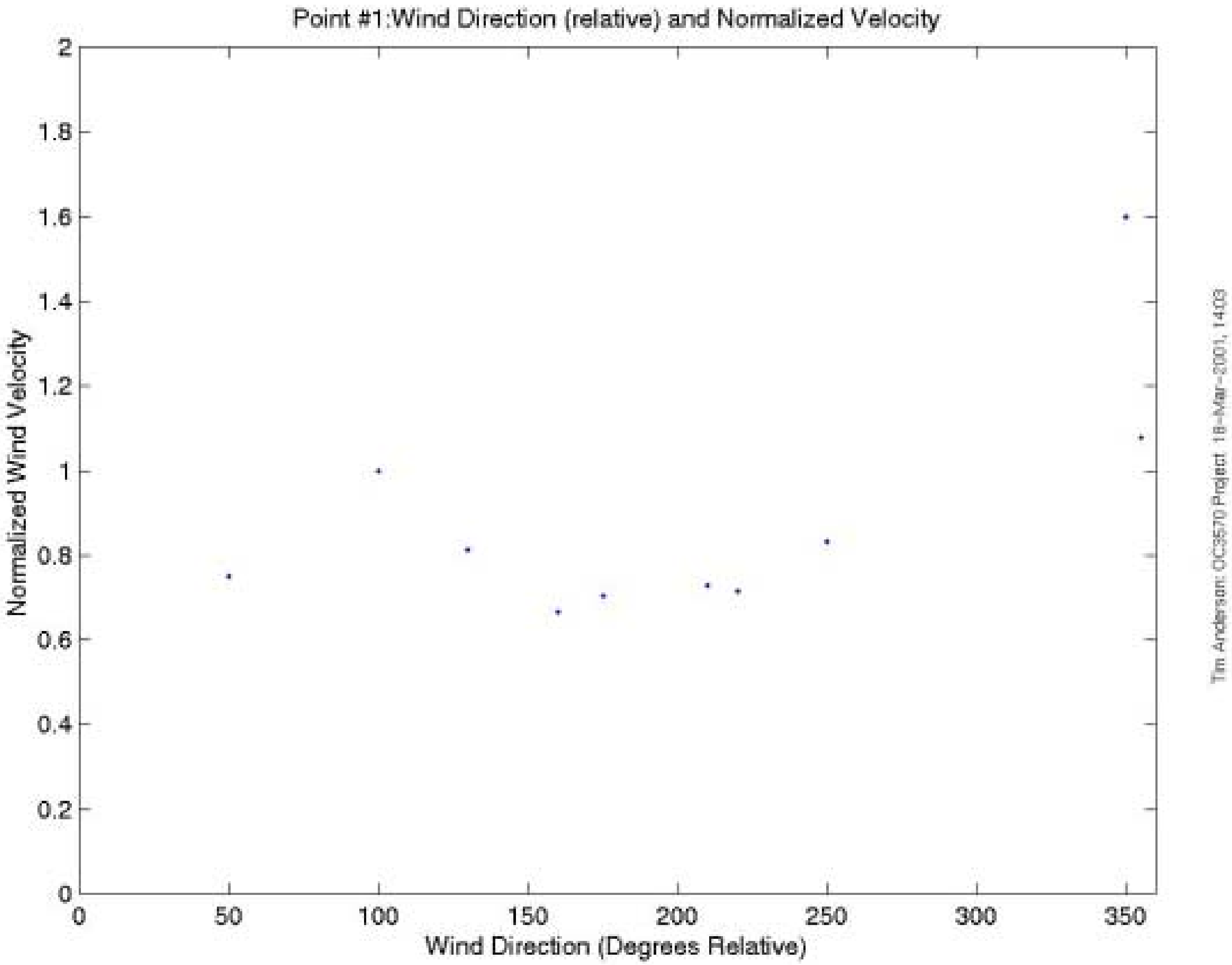
All positions: Wind Direction (relative)
Wind Direction (Degrees Relative)
Position
0
50
100
150
200
250
300
350
400
0
1
2
3
4
5
6
7
8
11 Feb 1345
11 Feb 1459
11 Feb 1543
11 Feb 1639
12 Feb 0030
12 Feb 0857
12 Feb 0910
12 Feb 1410
12 Feb 1539
12 Feb 1620
Tim Anderson: OC3570 Project 21-Mar-2001, 19:33

**Figure 3:**



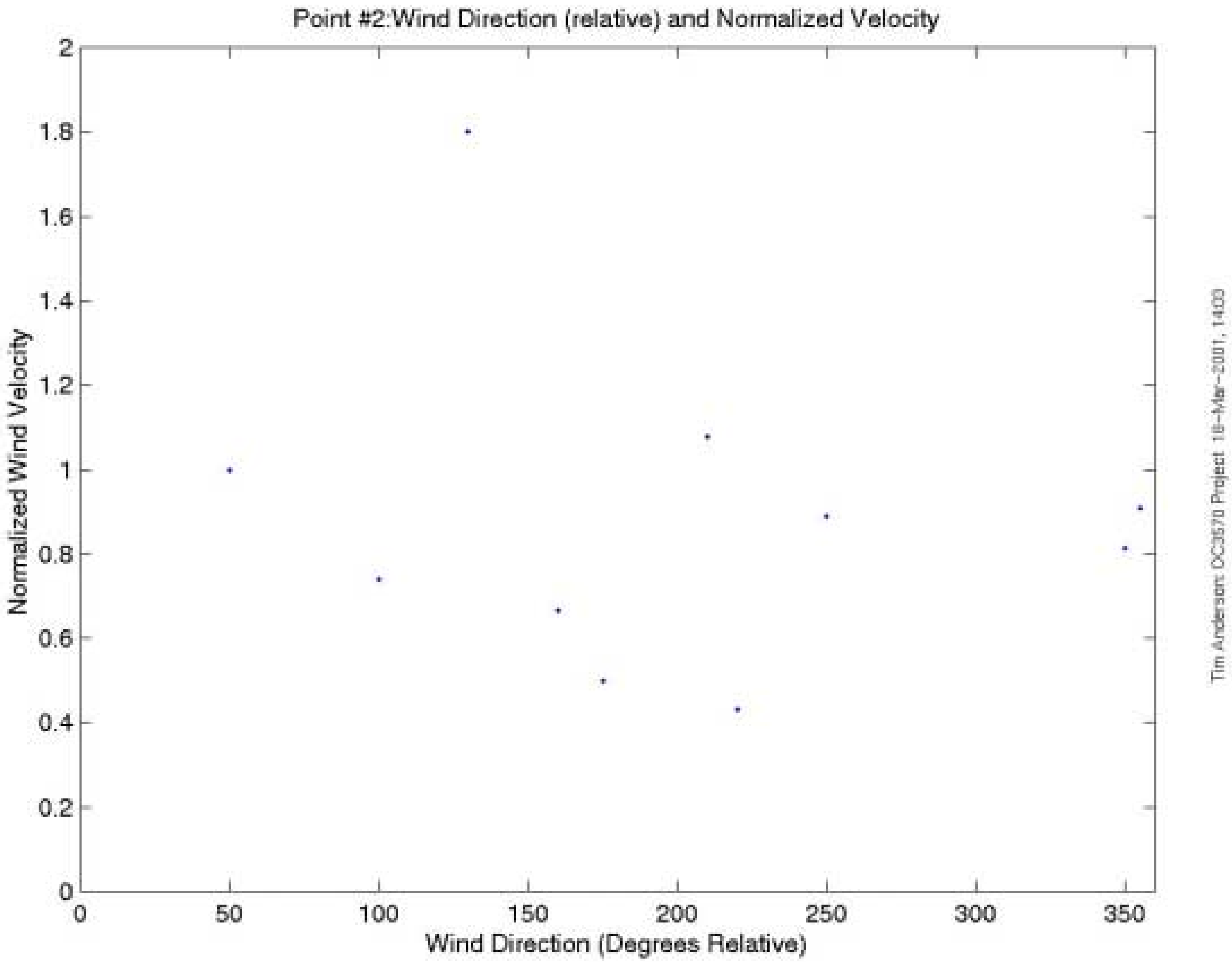
Wind Speed by Position
11 Feb 1345
11 Feb 1459
11 Feb 1543
11 Feb 1639
12 Feb 0030
12 Feb 0857
12 Feb 0910
12 Feb 1410
12 Feb 1539
12 Feb 1620
Wind Speeds (kts)
Position
0
2
4
6
8
10
12
14
16
18
20
0
1
2
3
4
5
6
7
8
Tim Anderson OC3570 Project 18-Mar-2001, 1403

**Figure 4:**



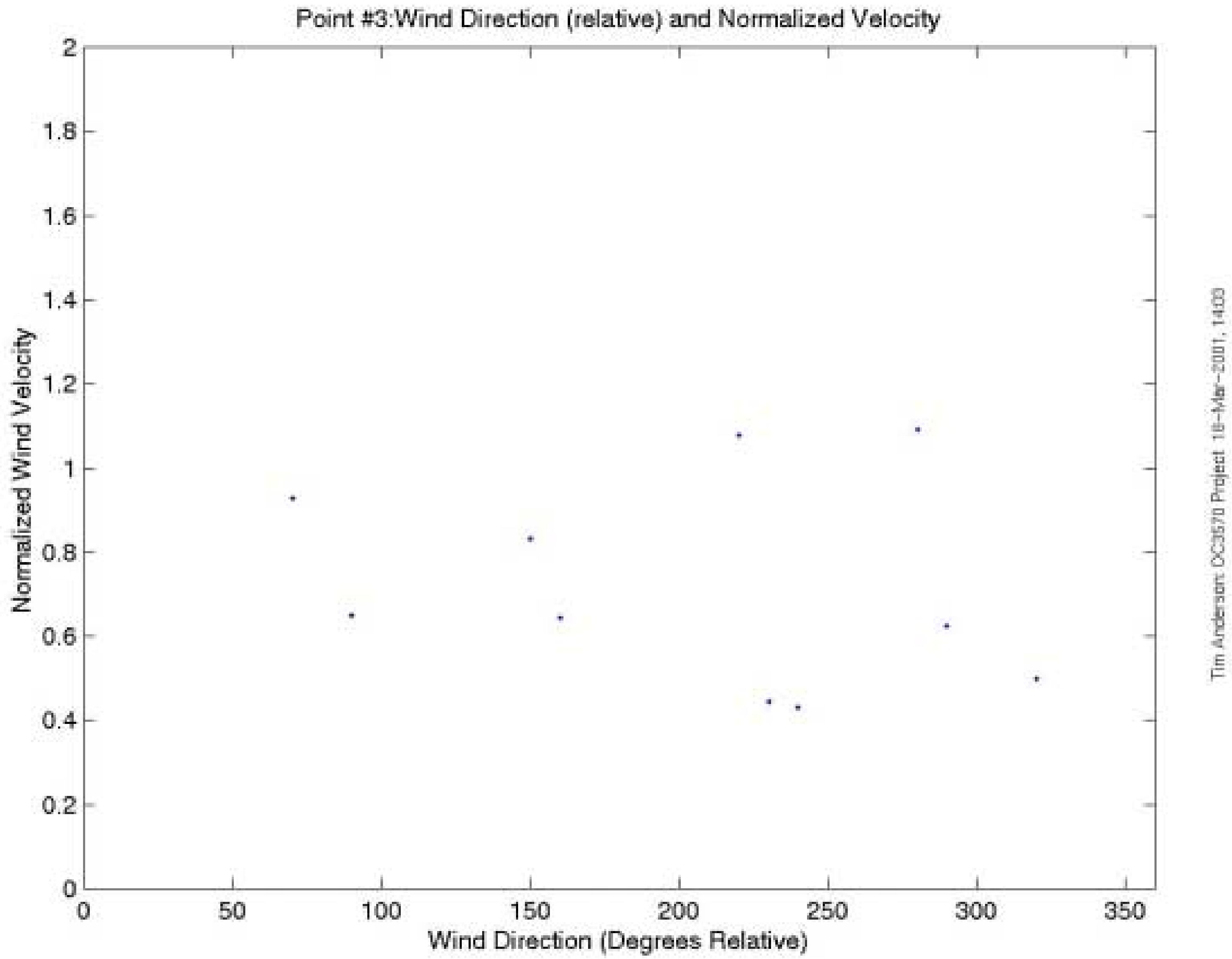
Point #1:Wind Direction (relative) and Normalized Velocity
Normalized Wind Velocity
Wind Direction (Degrees Relative)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
50
100
150
200
250
300
350
Tim Anderson: OC3570 Project 18-Mar-2001, 1403

**Figure 5:**



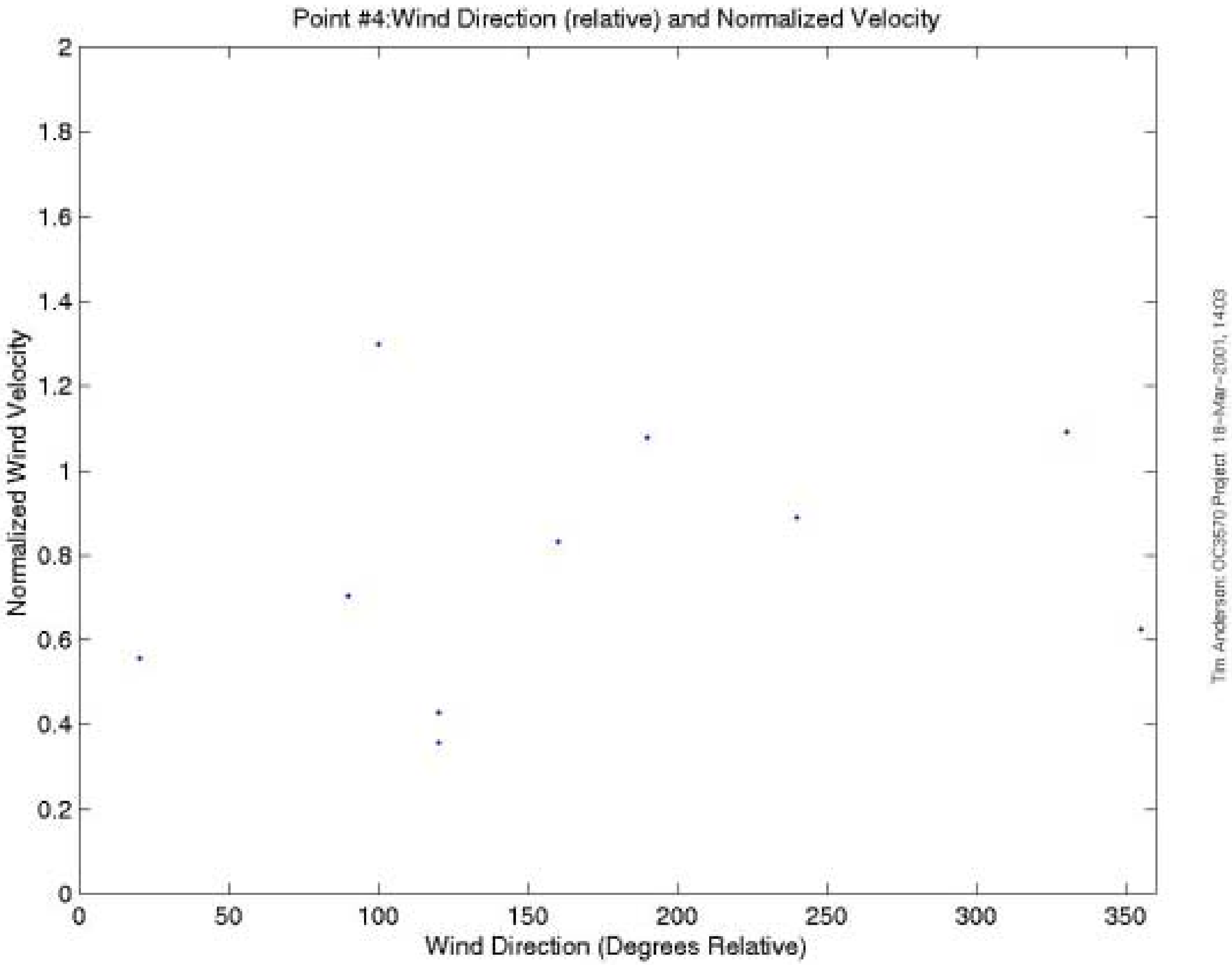
Point #2:Wind Direction (relative) and Normalized Velocity
Normalized Wind Velocity
Wind Direction (Degrees Relative)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
50
100
150
200
250
300
350
Tim Anderson: OC3570 Project 16-Mar-2001, 14:00

**Figure 6:**



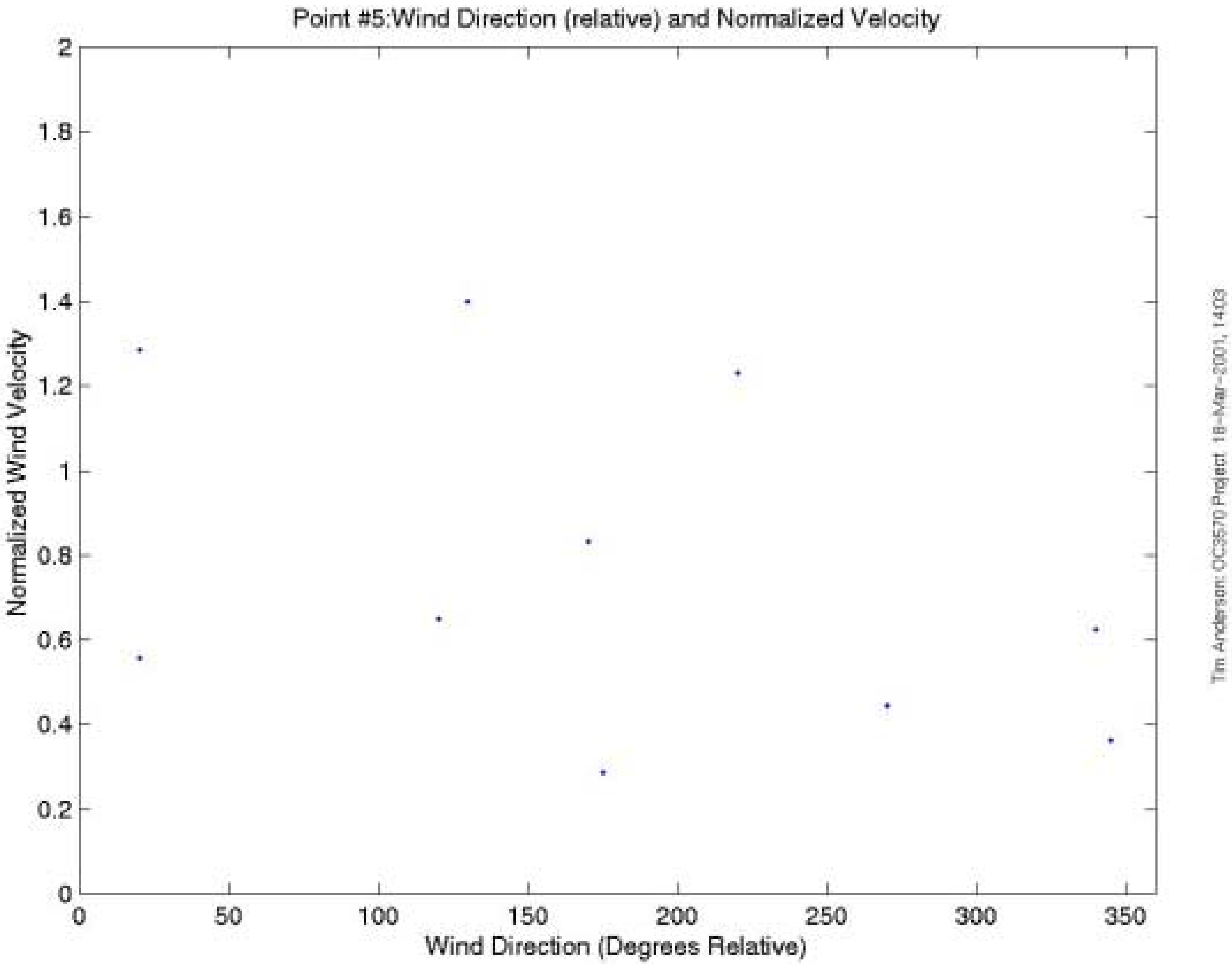
Point #3:Wind Direction (relative) and Normalized Velocity
Normalized Wind Velocity
Wind Direction (Degrees Relative)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
50
100
150
200
250
300
350
Tim Anderson: OC3570 Project 16-Mar-2001, 1430

**Figure 7:**



Point #4:Wind Direction (relative) and Normalized Velocity
Normalized Wind Velocity
Wind Direction (Degrees Relative)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
50
100
150
200
250
300
350
Tim Anderson: OC3570 Project 18-Mar-2001, 1403

**Figure 8:**



Point #5:Wind Direction (relative) and Normalized Velocity
Normalized Wind Velocity
Wind Direction (Degrees Relative)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
50
100
150
200
250
300
350
Tim Anderson: OC3570 Project 18-Mar-2001, 1403

**Figure 9:**

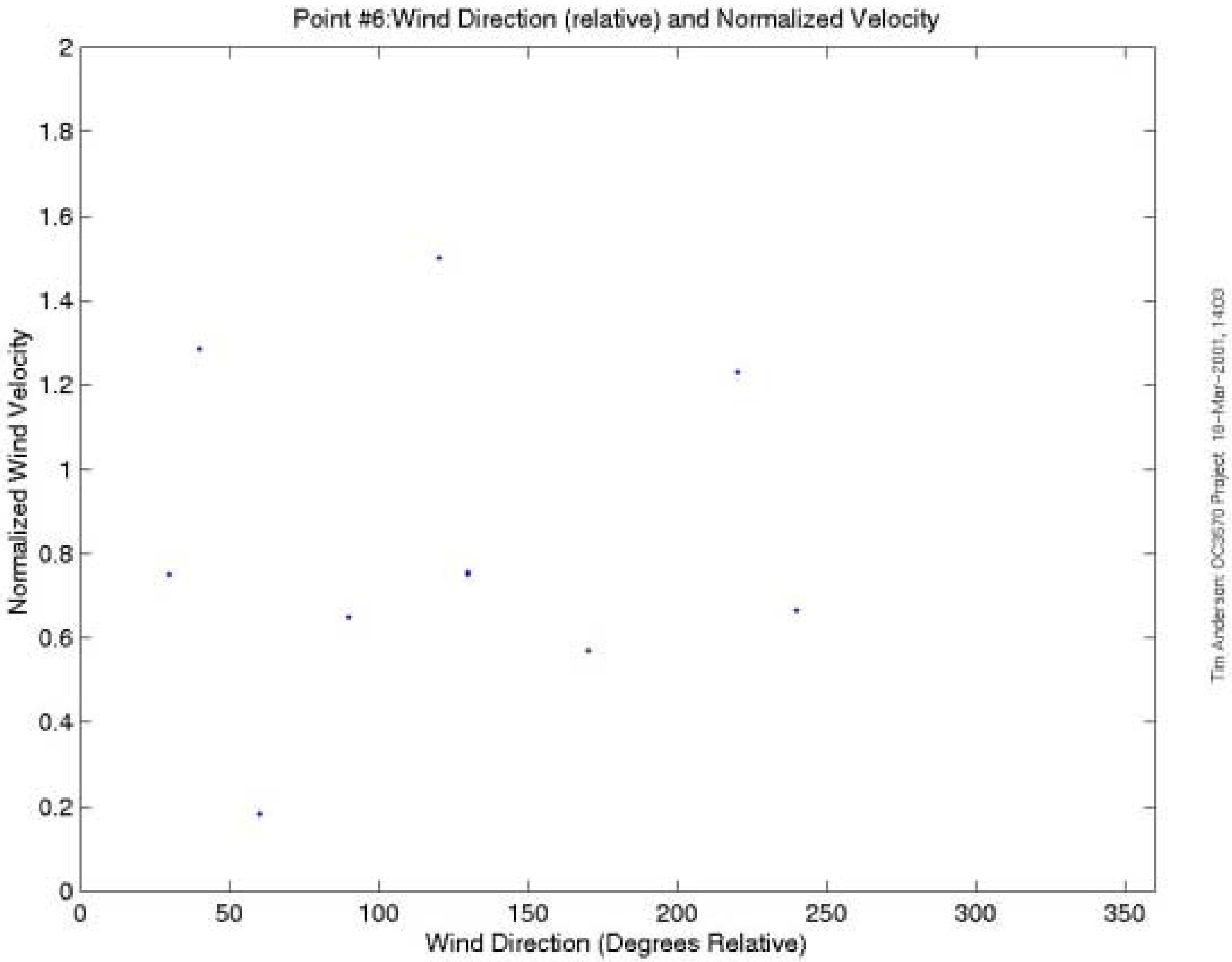
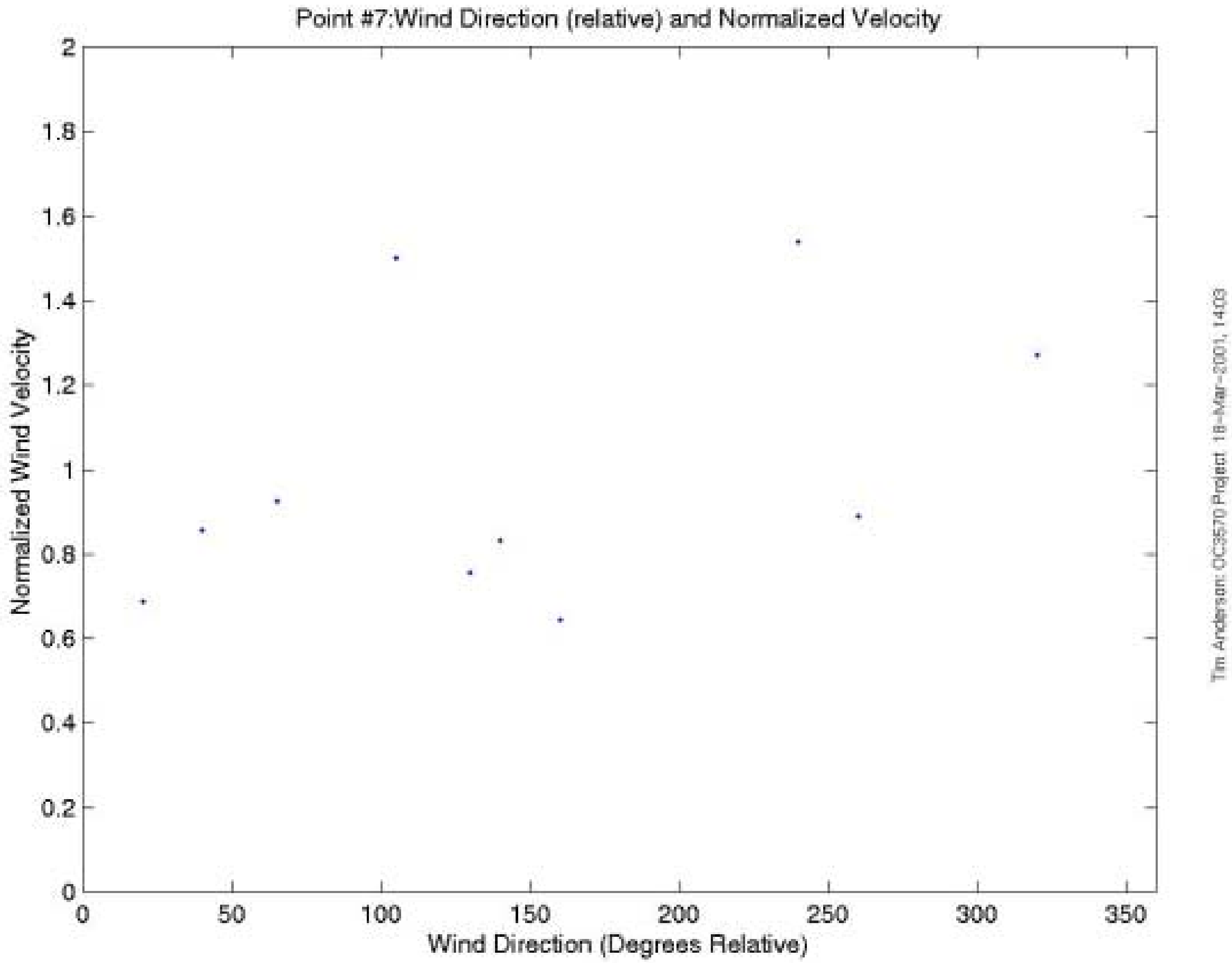
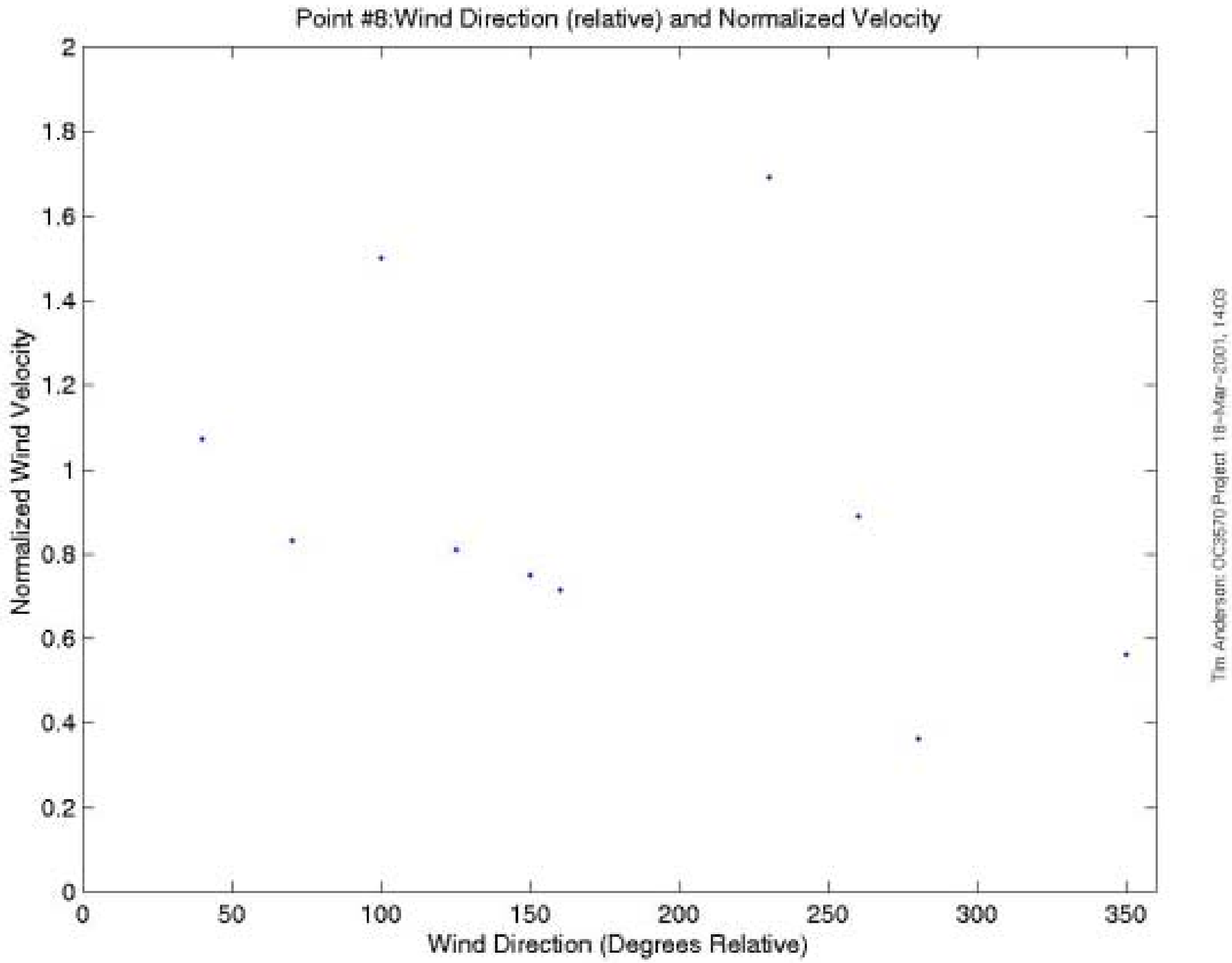

Point #6:Wind Direction (relative) and Normalized Velocity
Normalized Wind Velocity
Wind Direction (Degrees Relative)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
50
100
150
200
250
300
350
Tim Anderson: OC3570 Project 16-Mar-2001, 1403

**Figure 10:**



Point #7:Wind Direction (relative) and Normalized Velocity
Normalized Wind Velocity
Wind Direction (Degrees Relative)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
50
100
150
200
250
300
350
Tim Anderson: OC3570 Project 18-Mar-2001, 1403

**Figure 11:**



Point #8:Wind Direction (relative) and Normalized Velocity
Normalized Wind Velocity
Wind Direction (Degrees Relative)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250
300
350
Tim Anderson: OC3570 Project 18-Mar-2001, 1403